EFFECTS OF PARENTAL AGE ON THE LIFE CYCLE OF THE HOUSE FLY, MUSCA DOMESTICA LINNAEUS (DIPTERA: MUSCIDAE)[1]

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ABSTRACT

A parental age study of 2 strains of house flies, *Musca domestica*, was undertaken. In the CSMA strain 18 consecutive generations, from the first eggs laid in each generation, and 2 consecutive generations from the parental, the F_2, the F_4, and 3 from the F_9, obtained from the last eggs laid, were studied. In the Wilson strain, 12 consecutive generations from the first eggs laid, 9 from middle-aged parents, and 6 from old (18 days) parents were studied at 25° C., under constant conditions of lighting.

There was no parental age effect on the duration of the preimaginal stages, the larvae and the pupae each requiring 6 days. A reduction in the survival time occurred for adults of both strains when the first eggs laid in successive generations were selected. The use of the last viable eggs in the CSMA strain resulted in a decreased longevity and a reduction in reproductive capacity. No more than 3 consecutive generations could be reared.

Adult flies, at the age of 0, and 6 days, from both young and old parents were kept at different humidities without food. Those from young survived longer than those from old parents.

Parental age effects have been described by various investigators. Comfort (1953), using the vinegar fly *Drosophila subobscura,* stated that there was no change in longevity through successive generations of offspring obtained from old parents. Goetsch (1956) observed that in *D. melanogaster*, offspring from young lived longer than those from old parents. O'Brian (1961), using the same species, reported that the duration of

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the period for viable egg production was longer in offspring from young, than in those of middle-aged or old flies. Rockstein (1957) observed in the house fly, *Musca domestica,* that females from young parents had a greater longevity than those from old, but that male longevity was not effected. In 1959, after further investigations, he reported that males from old had a greater longevity than those from young parents.

Ludwig (1956) discovered in the mealworm, *Tenebrio molitor,* that the longevity and duration of larval life decreased in progeny of old beetles. Using the same species, Tracey (1958), reported that offspring from old had a significantly shorter life and a higher growth rate than those from young parents. Ludwig and Fiore (1960) verified Tracey's work and reported that these effects were not present until the parent beetles were 1 month old. Ludwig and Fiore (1961) studied offspring from isolated pairs and demonstrated that their previous findings were not caused by selection, since the same effects (with the exception of the shortening of adult life) were obtained. Fiore (1959) studying the dark mealworm, *Tenebrio obscurus,* found no consistent parental age effects upon the life cycle, but stated that the larvae from old had a slower rate of growth and failed to attain the same maximal weight as those from young parents.

The present experiment was initiated to determine whether parental age effects appear in the life cycle of the house fly, *M. domestica,* and to study the ability of flies, obtained from both young and old parents, to withstand unfavorable conditions of starvation and low humidity.

Materials and Methods

Two DDT-sensitive strains of house flies were utilized, a standard CSMA, and the Wilson strain.[3] They were maintained at 25° C., under constant lighting. The adults were reared in metal screened cages, 12 by 12 by 10.5 inches. To prevent overcrowding, less than 100 flies were placed in a cage. The adults were fed diluted sugar water and diluted non-fat, milk, prepared from Borden's Starlac. A wad of absorbent cotton, cov-

[3] The CSMA (Chemical Specialty Manufacturers Association) strain was obtained from Dr. Mark Henry, Boyce Thompson Institute for Plant Research, Yonkers, N. Y. The Wilson strain was obtained from Dr. Andrew J. Forgash, Rutgers University, New Brunswick, N. J.

ered by a 5 inch cotton gauze square, was placed in the milk which was then drained from the dish, leaving the saturated pad in the dish. The flies usually oviposited on the cotton pad. Eggs from the CSMA strain were transferred to half-pint culture bottles containing 50 ml. of water and an equal volume of Gaines dog meal. The top of the culture bottle was covered with heavy paper toweling. After 4 days, more meal was added to provide a suitable dry area for the larvae to pupate. Pupae were removed and placed in 50 ml. beakers covered with gauze, where emergence could be easily observed. On emergence the flies were released into cages. Dead flies were removed daily and time of survival and sex of each fly recorded. The flies of the Wilson strain were reared in the same fashion except that powered Kasco dog pellets were used as the larval medium.

In the CSMA strain, 18 consecutive generations were reared from the first eggs laid in each generation. Two consecutive generations, obtained from the last viable eggs, were reared from the parental, the F_2, the F_4, and 3 from the F_9.

Starting with the parental generation of the Wilson strain, 12 generations were reared consecutively from the first eggs. Nine consecutive generations were reared from eggs laid 5 days after the first eggs; these were called offspring from middle-aged parents. Finally, 6 consecutive generations were reared from the largest batch of eggs laid 18 or more days after emergence.

To compare the ability of offspring, from both young and old parents, to survive unfavorable environmental conditions, house flies of the CSMA strain were placed individually in small vials, which had a perforated metal cap. Eight such vials were placed in a 1-pint glass, preserving jar. A volume of 100 ml. of one of the following had been placed in each jar, resulting in the corresponding relative humidity value (Sweetman 1933): anhydrous $CaCl_2$, 0; saturated $CaCl_2$, 32; saturated $NaCO_2$, 62; saturated NaCl, 76; and H_2O, 96 percent. Flies within 2 hours of emergence, never fed as adults, and flies that were 6 days old, and fed as adults, were utilized.

Observations

The period from hatching to the appearance of the first adults was found to be 12 days for offspring from both young and old parents. This period consisted of 6 days of larval, and 6 of pupal life, using the appearance of the first pupa as the end of the larval, and the emergence of the first adult as the end of the pupal stage. The duration of the egg laying period averaged 15 days, and showed no consistent parental age effect. There was a reduction in the number of eggs laid as the adults aged in offspring from both young and old parents. Towards the end of the egg laying period, batches of viable were interspersed with non-viable eggs, and in both types there was a reduction in the number of eggs per batch. Generally, the eggs that were laid by older flies were less viable than those laid earlier. In most cases only a few larvae hatched from eggs produced by old flies, many of which never pupated, and of

TABLE 1

Group	Females			Males		
	No.	Average Survival (Days)	"t" value	No.	Average Survival (Days)	"t" value
P	45	28.6 ± 4.51		38	26.9 ± 2.07	
F_1	30	32.7 ± 3.16	0.75	32	27.3 ± 2.22	0.13
F_2	16	18.7 ± 2.17	1.98	17	16.2 ± 1.00	4.65
F_3	32	15.7 ± 1.80	2.74	37	15.2 ± 0.76	2.78
F_9	30	14.7 ± 1.61	2.95	37	18.6 ± 1.18	3.60
F_{18}	36	12.1 ± 0.91	3.58	30	12.7 ± 0.85	6.17

Average survival times, and the significance between these values, of adults of the parental generation compared with those of the first 3, the 9th, and the 18th generation obtained from the first eggs laid. Values are given with their standard errors.

those that did pupate, very few adults emerged. Fewer offspring survived to adulthood as their parents aged. Hence, consecutive generations of offspring from old parents died out. Thus, the rearing of offspring from old flies was difficult, especially when the last viable eggs were used. Under these conditions, no more than 3 consecutive generations could be obtained.

In the CSMA strain, the average survival time for the adults of the parental generation was compared with those of adults in 18 consecutive generations obtained from the first eggs laid. This comparison for the first 3, the 9th, and the 18th generation is given in table 1. There were no differences for the intermediate generations, hence they were not included. The survival time decreased, and following the second generation this decrease became significant. Significance was calculated by dividing the difference between the means by its standard error. If this ratio ("t" value) is more than 2, the means are statistically different. Thus, the selection of the first eggs laid proved to be detrimental in that the average survival time of the resulting adults diminished.

TABLE 2

Groups Compared	Females		Males	
	Average Survival (Days)	"t" value	Average Survival (Days)	"t" value
Parental	28.6 ± 4.51		26.9 ± 2.07	
From P				
F_1	16.3 ± 0.16	2.79	13.7 ± 0.82	6.00
F_2	12.7 ± 1.30	3.45	16.1 ± 1.08	4.69
From F_2				
F_1	15.8 ± 2.75	2.50	16.1 ± 2.12	3.85
F_2	9.7 ± 0.97	4.17	14.0 ± 0.73	5.86
From F_4				
F_1	20.7 ± 2.55	1.54	20.8 ± 3.03	1.69
F_2	12.3 ± 0.59	3.70	13.3 ± 0.62	6.18
From F_9				
F_1	13.9 ± 1.44	3.19	15.2 ± 1.65	4.50
F_2	13.4 ± 1.54	3.30	12.8 ± 1.11	6.13
F_3	12.4 ± 1.00	3.60	13.4 ± 1.28	5.62

Average survival times, and the significance between these values, of adults of the parental generation compared with those from old parents from 2 consecutive generations obtained from the parental, the F_2, the F_4, and 3 consecutive generations from the F_9, from young parents. Values are given with their standard errors.

In table 2 the average survival times of adult flies, obtained from the last viable eggs, are compared with those of the parental generation. These values were found to be significantly lower in 6 out of 7 cases. Thus, when the last viable eggs were selected there was a reduction in the duration of adult life.

In the Wilson strain, the average survival times of adults of the parental were compared with those of 12 consecutive generations, using the first eggs laid. This comparison for the 1st, 4th, 8th, and 12th generations is given in table 3. Since the intermediate generations showed no differences they were not included. The females, but not the males, showed a statistical decrease at the 12th generation. These values of the parental were also compared with those of offspring which developed from eggs laid 9 to 11 days after emergence, through 9 consecutive generations. No significant differences were found for either sex. Similar comparisons for eggs laid 18 days after emergence showed no differences through 6 consecutive generations.

TABLE 3

Group	Females			Males		
	No. of Flies	Average Survival (Days)	"t" value	No. of Flies	Average Survival (Days)	"t" value
P	33	20.3 ± 2.21		28	22.3 ± 2.09	
F_1	49	22.8 ± 1.74	0.89	38	23.1 ± 1.50	0.33
F_4	24	22.3 ± 2.80	0.73	22	25.3 ± 2.47	0.64
F_8	21	16.7 ± 2.97	0.97	25	22.2 ± 3.72	0.02
F_{12}	48	14.4 ± 1.25	2.36	37	19.4 ± 1.50	1.20

Average survival times, and the significance between these values, of adults of the parental compared with those of the 1st, 4th, 8th, and 12th generations obtained from the first eggs laid. Values are given with their standard errors.

The average survival times for adult flies obtained from young and old parents, and kept at different relative humidities, at 25° C., are compared in table 4. They are significantly higher in 0-day females from young than in those from old parents at each humidity. While those of 6-day females are significantly higher only at 76 and 96%. Comparisons for the survival times of 0-day males showed significant differences at all humidities, except 62%, while with 6-day males a difference appeared only at 96%. Thus, recently emerged house flies from young parents are better able to survive unfavorable conditions than those from old parents.

Discussion

The observation that there were no consistent differences in the duration of the larval and pupal periods of offspring from young and old parents is in agreement with the work of Wilkes, Bucher, Cameron, and West (1948) who stated that the length of the larval and pupal periods of the house fly varied with environment, but under standard conditions remained constant.

Rockstein (1959) also pointed out that in this species the developmental time for the first adults to emerge is always constant. Similarly, O'Brian (1961) reported that in *Drosophila melanogaster,* the age of the parents had no effect on the duration of the preimaginal stages.

The observation that with increasing parental age there is a decrease in reproductive capacity agrees with the work of

TABLE 4

% R. H.	Age in Days	From Young Parents: No. of Flies	From Young Parents: Average Survival (Days)	From Old Parents: No. of Flies	From Old Parents: Average Survival (Days)	"t" value
Females						
0	0	128	2.12 ± 0.06	36	1.77 ± 0.07	3.8
	6	128	1.74 ± 0.04	21	1.62 ± 0.10	0.9
32	0	128	2.15 ± 0.05	36	1.66 ± 0.10	4.4
	6	128	1.58 ± 0.05	21	1.54 ± 0.10	0.3
62	0	128	2.62 ± 0.08	36	1.91 ± 0.10	5.4
	6	128	1.45 ± 0.04	21	1.45 ± 0.10	0.0
76	0	128	2.54 ± 0.06	36	1.91 ± 0.10	5.7
	6	128	1.48 ± 0.06	21	1.25 ± 0.09	2.1
96	0	128	2.53 ± 0.08	36	1.80 ± 0.08	6.4
	6	128	1.81 ± 0.03	21	1.50 ± 0.10	3.0
Males						
0	0	128	1.81 ± 0.06	36	1.58 ± 0.08	2.3
	6	128	1.65 ± 0.05	21	1.45 ± 0.10	1.8
32	0	128	1.98 ± 0.03	36	1.41 ± 0.08	8.1
	6	128	1.13 ± 0.03	21	1.29 ± 0.09	1.7
62	0	128	1.84 ± 0.07	36	1.53 ± 0.09	1.3
	6	128	1.04 ± 0.04	21	1.20 ± 0.06	1.7
76	0	128	1.85 ± 0.08	36	1.69 ± 0.08	2.5
	6	128	1.31 ± 0.04	21	1.20 ± 0.06	1.5
96	0	128	2.04 ± 0.09	36	1.69 ± 0.09	2.7
	6	128	1.83 ± 0.07	21	1.58 ± 0.10	2.0

Average survival time of flies, obtained from young and old parents, exposed to different relative humidities, at 25° C. Values are given with their standard errors.

Richards and Kolderic (1957) who stated that in the milkweed bug, *Oncopeltus fasciatus,* fewer eggs were laid late in the reproductive period and that these had lower viability than those obtained from middle-aged parents. Ludwig and Fiore (1961) reported that in the mealworm, *Tenebrio molitor,* the percentage of viable eggs was lower when obtained from beetles 12 weeks after emergence than in those from younger parents.

The detrimental effect on adult survival resulting from the selection of the first eggs is in agreement with the observations of Richards and Kolderic (1957) who found that fewer eggs were laid early in the reproductive period of the milkweed bug, *O. fasciatus,* and these had lower hatching percentages, weighed less, and had a longer developmental time than those from middle-aged parents. Liles (1961) working on the mosquito, *Aëdes aegypti,* reported that offspring from the first batch of eggs had reduced longevities and reproductive capacities than those from 15–20 day old parents.

The detrimental effects on longevity obtained by selecting the last eggs through successive generations concurs with the studies by Goetsch (1956) on *D. melanogaster.* He noted that offspring from old had a shorter length of life than those from young parents. O'Brian (1961), using the same species, reported that the selection of offspring from old parents resulted in a shortening of the adult life within the first two generations over that of flies from middle-aged parents. He also pointed out a reduction in the reproductive period of offspring obtained from middle-aged and old, over that of flies from young parents.

The observation, on offspring from middle-aged and from old parents of the Wilson strain, that there was no reduction in average survival may indicate that the 18-day selection was not late enough to show a parental age effect. However, Comfort (1957) reported that there were no changes in the longevity of *D. subobscura,* which were continually selected from 30-day old parents.

The ability of offspring from young to better withstand unfavorable conditions than those from old parents suggests that parental age may be a factor which modifies ability to survive other unfavorable factors, such as exposure to low temperatures or to insecticides.

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RED FACE DEPARTMENT

In the Journal of the New York Entomological Society, Vol. LXX, No. 2, June 1962, page 67 the fact that both **Dr. Rozen** and **Dr. Rindge** are associated with the American Museum of Natural History was inadvertently omitted.